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Support program to the cotton seed supply chain in Sub-Saharan African countries

Work Package 1: Baseline studies

The Cottonseed Sector in Ethiopia

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The Ethiopian CottonSeed System
Description, analysis and recommendations

Preamble

This document draws a synthetic view of the seed cotton sector in Ethiopia. It summarizes the information from different stakeholders during mission and detailed report produced, that has already been shared with GIZ.

The report presents current status of cotton production in Ethiopia, it provides details on legal arrangements and practices on seed multiplication, processing and breeding. Finally, the document points out specific challenges and suggests possibilities of action.

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Framework conditions

National production

During the 70s, cotton was grown on about 140,000 ha. The area then dropped to about 40,000 ha from the mid 80ies to the beginning of the century, where the sector raised interest of private investors and entrepreneurs (2003-2004). After another drop due to poor international prices, the area planted has more recently been fluctuating around 75 to 80,000 ha, depending on the relative price of lint and inputs (Figure 1).

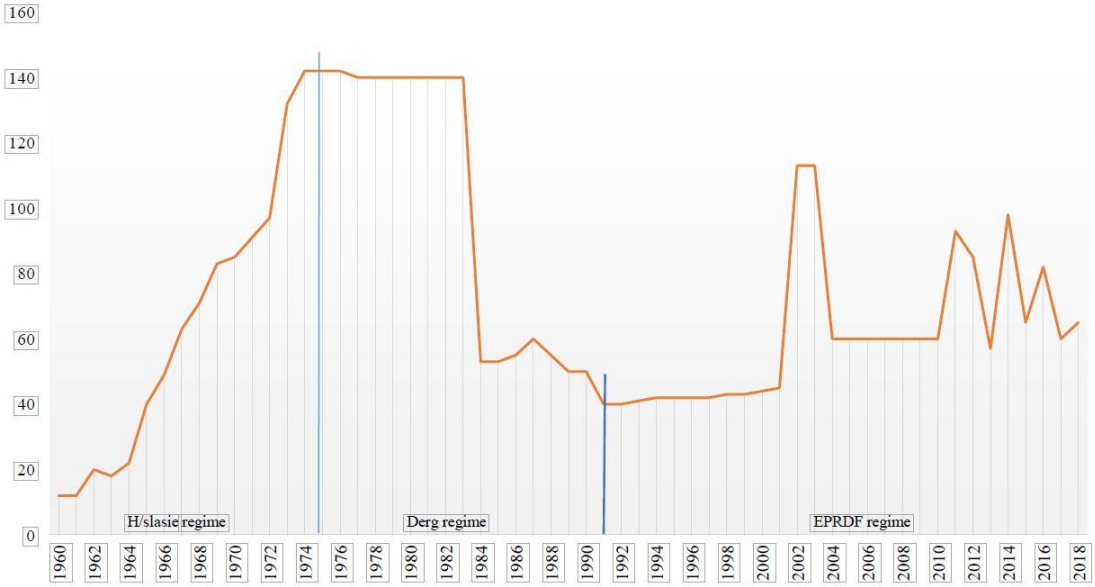

Figure 1. History of cotton planting in Ethiopia (Source: ETIDI).

For the past 10 years, the area planted has been varying between 60,000 and 100,000 ha, with a peak in 2014 and a low in 2013 and 2017. The variations can be explained by the fluctuations of the market price, or anticipations, which are more generalized among large scale farmers.

Today, cotton is mostly grown in 6 regions, Amhara, Afar, Tigray, SNNPR (Southern Nations, Nationalities, and Peoples' Region), Benishangul-Gumaz and Gambela.

The major regions for rainfed cotton are Amhara (with around 30,000 ha) and Tigray (around 15,000 ha). For irrigated cotton, Afar (Awash valley, with 15,000 ha) and SNNPR (Omo valley, with 10,000 ha) are leading.

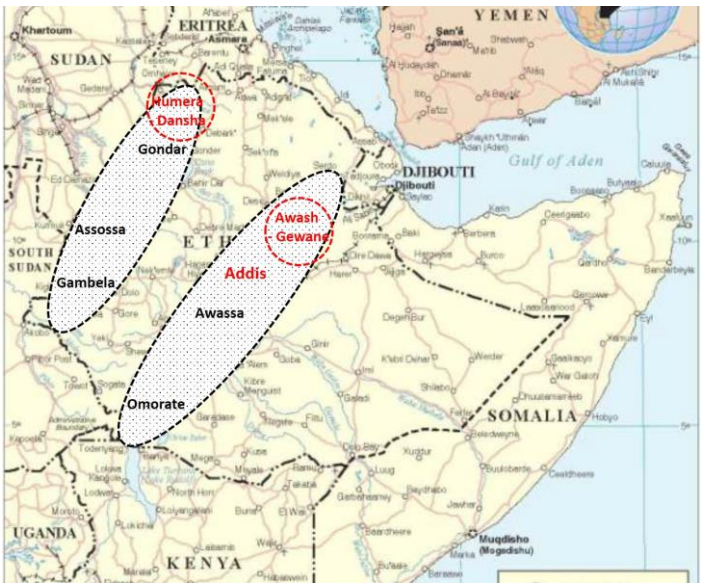

Figure 2. Major cotton production area in Ethiopia (in grey).

Cotton production

The production systems are quite diversified. About 26% of the total cotton area benefit of irrigation facilities and harvest 35 to 40% of the national production. The other 74% are run with natural rainfall.

Very large farms manage more than 200 ha of crops. They have been developed by investors or taken over from the state in the early 2000s. These farms are highly mechanized. At the opposite, very small family farms grow in general less than 1 ha, and they have only access to oxen draught equipment. Weeding and harvesting are still manual everywhere, and labour intensive.

Box 1. An irrigated large cotton farm in Afar
The farm was created in 2008. It now grows about 250 to 350 ha of cotton, and employs around 90 permanent staff, including a Farm manager. Mechanization is fully developed until the crop is in its early stage, but weeding and picking require 400 to 600 temporary workers.
The farm grows Deltapine 90 and Claudia varieties. The crop is machine planted in rows, at a 90 x 20 cm spacing, in the May-June period, after ploughing, ridging and pre-planting irrigation. The crop is thinned at 3 p.p.hole. Irrigation is adjusted to the natural rainfall. It also serves to control the crop growth, as no regulator is used. Usually, irrigation is conducted every 2 or 3 weeks, depending on growth stage and water requirement, which is generally more during the flowering period. Pest control requires 8 to 12 sprays.
The yield average was 3.3 tons of SC/ha in 2019.

Main challenges: flooding caused by the Awash river, casual staff recruitment and transport, pest control specially Pink bollworm (yield reduction and cotton quality loss).

About 1000 of these large farms manage approx. 70% of all the cotton fields, 90% of the fields with irrigation facilities, and 60% of the rainfed area. These farms generate a significant level of employment (2.7 p./ha), which is relatively comparable to the small farms (2.4 p./ha). In average, they have planted about 50-60 ha of cotton during the 2011-2015 period.

Box 2. A rainfed large cotton farm in Tigray
The farm belongs to a company which owns also another farm, a ginning plant and a textile factory. The two farms together grow 6000 ha of crops, in a rotation with cotton, sesame, green gram and sorghum. Cotton may represent up to 50% of the planted area, depending on rainfall prediction, and market expectation. It also has a Farm manager, and a number of casual workers for weeding and picking.
The farm grows Acala SJ2, on fast drying lands, and Deltapine 90 on good land, whereas Claudia variety has been introduced. The crop is machine sown, mostly broadcasted, after ploughing and harrowing. The rate of fertilizer is 100 NPS/ha, and 50 kg Urea.
The yield average was 1.3 ton of SC/ha in 2019.

Main challenges:, little landscape management (issues of erosion control), access to chemicals in particular for weed control

The national average yields are estimated at 2.5 tons/ha of seed cotton with irrigation, and 1.5 ton in rainfed conditions. The yields obtained by the small farmers are quite similar to those obtained by the large scale farmers under irrigation, but they are estimated to be inferior by about 0.3 to 0.4 ton/ha in rainfed conditions (1.40 ton/ha compared to 1,70). Considering the limited amounts of fertilizers and pesticides used, this performance is relatively high compared with major African countries. However, accessible information cannot help to distinguish between possible causes such as fertile volcanic soils, favorable rainfall or climate pattern, limited pest pressure, or even broadcast planting, which is

very common in rainfed areas. Moreover, yield estimates could also be biased as they are more difficult to get with small scale farmers, who contribute more to the production in the rainfed areas.

Smaller farms are generally gathered in Cooperatives and Unions, or under contract with large farms or ginneries, and even textile mills like Kombolcha Textile Share Company (KTSC).

With an average seed cotton yield at 1.7 tons/ha, regional averages vary from 1.5 to 2.2 tons/ha according to the presence of irrigation facilities (table 1). The small scale farms play a significant role in cotton production in the Amhara region, and to a lesser extent, in the SNNPR.

Table 1 – Cotton production in Ethiopia

Region	Area (ha)	Yield (ton SC/ha)	% Area managed under			
			large scale	small scale	irrigation	Rainfed
Amhara	27831	1,59	39%	61%	9%	91%
Tigray	12397	1,47	93%	7%	-	100%
Benishangul	6229	1,54	100%	-	-	100%
Gambela	5653	1,46	100%	-	-	100%
Afar	16734	2,22	84%	16%	100%	-
SNNPR	10769	1,76	73%	27%	64%	100%
Oromia	212	2,10	100%	-	100%	100%
Together	**79826**	**1,70**	**70%**	**30%**	**26%**	**74%**

Box 3. A rainfed small cotton farm in Tigray

The farmer has been involved in cotton for more than 40 years. He is growing a quarter of ha out of 5 in total. He also grows finger millet, tef, sorghum, and green gram. His two oxen are mainly used for ploughing and ridging.

The crop is sown by hand, either broadcasted or in rows which is more labour demanding, after ploughing. In 2019, the farmer grew the variety Claudia, supplied by the cooperative through an NGO. He applied 60 NPS/ha, 24 kg Urea and sprayed five times (3 with chemicals and 2 with neem decoction). In the old days, he could gin manually some seed cotton to produce his own seed for planting.

The yield average was estimated at 2.4 ton of SC/ha in 2019.

Main challenges: cotton price not very attractive unless niche markets, access to chemicals for pest control

After SOFRECO's report; average 2011-2015 and 2014-2015 for % irrigation vs rainfed

Saw-gins are predominant in Ethiopia (70%), but, in general, the old equipment has been poorly maintained because of uneasy access to imported spare parts. Altogether the national ginning capacity can be estimated at 200 to 300,000 tons of SC, and it is presently used at about 50%.

Box 4. ECPEGA

The Ethiopian Cotton Producers, Ginners and Exporters Association is a business membership organization. Its mission is to lobby for its members, and to provide information (technical) to them.

The Board is composed of 11 members representatives of the 6 main cotton producing regions, ginneries, cooperatives, commercial farms, and middle range unions.

Its Executive Secretary was Mr. Asefa Aga during our visit (now resigned).

Figure 3. Mechanized farm in the Afar region.

Figure 4. Large farms with open fields of broadcast cotton in the rainfed areas, Tigray

Figure 5. Typical aspect of seed cotton picked by casual labour.

National strategy

The Growth and Transformation Plan (GTP 2), elaborated for the period 2015-2020 by the government of Ethiopia, underlined its big potential for cotton cultivation, and expressed a strong political desire to develop the crop together with the industrial capacity of the country, up to 1 M. tons of seed cotton or more.

Based on this, a National Cotton Development Strategy and Road Map has been developed, covering the 2018-2032 period. The strategy notes that Ethiopia is the second larger consumer of cotton in Africa, and a net importer to satisfy the local demand of the textile mills. As labour and power costs are relatively low, it has a strong potential to expand its spinning sector to become one of the largest industrial users of cotton.

The country has also a significant potential for cotton production, which should be driven by the domestic spinning industry. No other country in Africa has the same potential to grow a wide range of varieties, under various growing conditions, different agro-climatic zones, rainfed or irrigated.

The policy proposes to develop and monitor a Code of conduct, audit and best practices for the investors in cotton, including in cotton production on large scale farms. It suggests to create a strong and functional linkage between key cotton actors, at the national level (Ministries, Banks, Custom Authority, Universities, Local authorities, *etc*.) and with international organizations (ICAC, A.C.A., ICA, PAPA, FAO, *etc*.).

Refering to the seed system, the strategy proposes to **s**et up a formal supply system for certified cotton seeds through selected private producers closely linked to the research centres. It also recommends to capacitate the resources of cotton research (human, physical, and budget), and establish cotton research centers and sub-centres in major cotton producing regions of Ethiopia. Its budget should increase progressively (by 10-30% / year), and make possible to revigorate the existing laboratories at WARC and establish laboratories for the new centres. Priorities in research should be put on the development of new production and productivity boosting technologies such as heat- and drought- resistant seeds adaptable to various areas of cotton production in Ethiopia.

Coordination

The Ethiopian Textile Industry Development Institute (ETIDI) has a central role for the cotton sector. Beyond the direct support to the stakeholders, it is also playing a coordination role in the importation of inputs (chemicals, fertilizers…), labour, and policy issues. It organizes meetings with interested stakeholders on quality, chemicals and the seed system. ETIDI suggests to the Ministry of Agriculture the farmers that deserve to be registered as seed multipliers and be issued a Certificate of competence. The institute is also managing, at its headquarters in Addis, a High Volume Instrument (HVI) laboratory where fiber characteristics can be controlled at a fast speed. The lab is affiliated to a round test coordinated by the US Department of Agriculture (USDA).

The Ethiopian Industrial Input Development Enterprise (EIIDE[1]) is in charge of setting a fiber price for the local market, to supply the textile industry. The price is based on 11 parameters which include the intrinsic quality of the fiber and its cleanliness. It provides an indicator for the transactions passed throughout the country.

[1] Created in 2014, by Regulation No 328/2014. Its purposes are in particular 1/ to establish, administer and transfer, whenever necessary, enterprises which ensure supply of industrial input; 2/ to supply industrial inputs by manufacturing domestically and abroad; 3/ to supply industrial inputs by purchasing from the local and international market (…); 6/ to implement strong supply chain management to ensure dynamic and efficient industrial inputs delivery (…).

Box 5. ETIDI
It was established by the Regulation 180/2010 as the Ethiopian Textile Industry Development Institute.
It is accountable to the Ministry of Trade and Industry, in order to better link the development of the sector with the creation of jobs in the textile industry.
Objective: Enabling the Ethiopian textile industry to be competent in the global market through investment support, production capacity building and marketing support.
Mission : Enabling the Ethiopian textile industry competent in the global market by providing sustained investment expansion, consultancy, training research and development laboratory and marketing support and services.
Its staff is under a Director general. The Director for Cotton development is managing 16 technical experts organized in 4 teams (Agronomy and research / Extension / Irrigation / Economics & Mechanization). The main activities are to produce statistics on the sector and support small holders and cotton producers in relation with the extension services, based in the regions. It provides training of trainers, or capacitate employees of the big farms, in the field of agronomy, crop protection, training method, farm management or planning (for big farmers), farm machinery or oxen-drawn equipment.

Main challenges: increase in cotton production, link between production and textile industry

Cottonseed multiplication

Regulation

The Seed Proclamation 782/2013, adopted in 2013, has been completed in 2016 by the Seed Regulation 375/2016. Together, they set the national rules for the activities related to seed production. Their application is under the responsibility of the Ministry of Agriculture (MoA).

The law introduces the distinction between "approved seed" that are certified, after inspection, to be conform to the Ethiopian seed standards, and "quality declared seed" that have been produced by registered farmers, who follow an internal quality control process.

It also distinguishes between the first generation of “breeder’s seed", produced under the control of the plant breeder, and the following generations "pre-basic seed", "basic seed", and finally the "certified seed", which are used for the commercial crop and can be obtained from first, second or third generation of basic seed.

A variety can be multiplied, produced or supplied to domestic market, after its release by a National Variety Release Committee (NVRC) set by the MoA. The decision is based on the reports prepared by the National Performance Trial Evaluation Technical Committee, from the results of tests conducted for a minimum of two seasons in at least three sites having similar agro-ecology, or, if the variety has already been released outside of Ethiopia, for at least one season in related agro-ecological zone. The reports are looking at distinctness, uniformity, stability (DUS) and value for cultivation and use. Once registered, the variety enters the National Variety Register (NVR). Besides, if a variety is considered as GMO, it has to comply with the applicable legislation from the Environmental Protection Authority, under the Ministry of Environment and Forest.

To become seed producer, one has to get a certificate of competence, based, in particular, on the ability to establish a quality control process, including keeping samples of the seed produced for possible inspection during one year.

The MoA is issuing the Certificates for any seed actor operating in more than one region of Ethiopia. It also delivers certificates for seed exporters or importers, for imported or exported seed, as well as the specific permits. The regional authorities are delivering the certificates for the local seed actors, and certificates of seed quality for the certified seed and quality declared seed for the domestic market.

The MoA is in charge of maintaining a national database on seed production (quantities, responsibilities, areas, register of producers and distributors) to facilitate integrated planning. It also coordinates the quality control, with the support of a National seed testing laboratory, and in liaison with appointed seed inspectors, regional laboratories and authorities. The seed inspectors must verify the compliance with the law and its directives.

Certified seeds must be labelled with the name and address of the organization, the certificate number, the crop type and variety name, the seed class, a reference number, the net weight of seed, the year of production, date of sealing, expiry date and warning text if dressed with drug. The labels are different in colors depending on the multiplication stage: white with violet stripe for breeder or pre-basic seed, white for basic seed, blue for the first generation of certified seed and red for the following generations.

Standards

Cottonseed standards have been set by the Ethiopian Standard Agency Requirements in relation with the Ministry of Agriculture under the code ES 441-2000.

The seed lots have to be free from contaminated, infested or infected seeds with *Ascochyta gossypii* (seedling or leaf blight); *Fusarium oxysporium* (wilt); *Xanthomonas malvacearum* (Black arm, angular leaf spot); *Glomerella gossypii* (Boll rot, anthracnose); and other seed borne diseases and parasitic weed seeds.
The standards recommend a minimum of two field inspections for all classes of seed production early at flowering and maturity.

Table 2 and table 3 summarize the field and lab requirements to be fulfilled.

Table 2 - Minimum field requirements for cottonseed certification

Characteristics	A	B	C1	C2	C3	C4	E
Rotation (min, year)	3	2	2	1	1	1	1
Isolation (min, meters)	400	400	200	200	200	100	100
Off types & other cultivar (max %)	0.01	0.02	0.03	0.05	0.05	0.05	0.1

A for Breeder/ pre basic seed; B for Basic seed; C1 to C4 for Certified seed; E for Commercial or Emergency class

Table 3 - Minimum requirements in the laboratory for cottonseed certification

Characteristics	A	B	C1	C2	C3	C4	E	Method of test
Pure seed (min %)	99	98	98	98	98	97	97	ES 472
Other crop seed (max %)	0.5	0.1	0.3	0.5	0.5	0.5	1	ES 473
Weed seed (max %)	N.S	0.2	0.3	0.5	0.5	0.5	1	ES 472
Infected/infested/seeds (max %)	N.S	N.S	N.S	N.S	N.S	N.S	N.S	ES 476
Inert matter (max %)	1	2	2	2	2	2	2	ES 472
Germination (min %)	85	80	80	75	75	75	70	ES 474 / ES 475
Verification of species cultivar	-	-	-	-	-	-	-	ES 477
Moisture content (max %)	8	8	8	8	8	8	8	ES 478

N.S = Not specified
A for Breeder/ pre basic seed; B for Basic seed; C1 to C4 for Certified seed; E for Commercial or Emergency class
ES 474: Germination test; ES 475: Biochemical test for viability; ES 475: Determination of Seed health

Seed sector at a glance

Private companies, commercial farms, ginneries, or independent seed suppliers, are predominant in the seed sector, as seed processors. The main public actors are Werer Agricultural Research Center (WARC), which multiply the pre basic seed of selected varieties, and ETIDI, which plays a coordination role with the Ministry of Agriculture. Recently, limited Non-Governmental organizations, like Solidaridad, have also played a role in variety dissemination. At the end, Unions and cooperatives disseminate the seed, that they get from the private seed companies or commercial farms.

Informal seed sector is by far the largest seed supply chain. Delinted and fuzzy seeds have been in circulation informally for decades. However, with the change in legislation, there is a need to better formalize the business in the sector. The seed producers must now register as seed suppliers with Competency certificate and business license.

Licensed commercial farms and suppliers supply seeds to medium and large scale and small scale farmers in the Western part of the cotton growing regions (Humera, Metema, Benishangul Gumuz, Gambela) where seedling pest called flea beetle is devastating at an early seedling stage.

In Metema (Amhara region) and Arbaminch (SNNPR region), the small scale farmers are using massively fuzzy seed from more informal channels, like own source, bought from ginneries, local markets and fellow farmers. Cooperatives, commercial farmers, ginners and traders (in local market) supply seed informally.

Policy, coordination and control

The seed production is under the loose control of ETIDI and the Ministry of Agriculture (MoA).

Seed production is tax free so far to incentivize farmers and farms producing seed. Ethiopian government has a policy of tax exemption for seeds of any crops and recently it applied to 600 farm inputs, equipment and machineries including seed processing and post-harvest handling.

The varieties to be grown commercially and multiplied are decided by two departments of EIAR, with the Cotton research: the Technology Multiplication department and the Technology extension, dissemination and promotion department. The cotton development wing of ETIDI is also involved, in lobbying EIAR to do the maintenance and multiplication of preferred varieties.

Research is producing the early generations seeds (Breeder's and Pre-basic), and passes them to registered seed processors who multiply the following generations (Basic and Certified). ETIDI is recommending to the Ministry of Agriculture or local authorities the farmers that deserve to be issued a Certificate of competence. The seed producers are usually large scale farmers, ginners or farmers-ginners.

When a processor has been attributed a Certificate of Competence, it has the right to produce seed, process and sale them as 'Quality Declared Seeds' (QDS). With this category of seed, quality control is insured by the processor himself, external inspection is non-existent.

Seed quality control is supervised by the Plant Health Regulatory directorate at the MoA. It runs in Addis a national seed laboratory, which is accredited by the International Seed Testing Association (ISTA). In the regions, 13 seed labs and inspection services are supervised by the MoA for harmonization purposes. In the cotton growing area, labs are present at Gondar, Gambela, for the seed outgrowers, and Addis for Afar. In practice, the laws passed through the Seed Proclamation and Regulation are not yet quite functional and the Directorate has few – or none - activities on cottonseed multiplication and distribution. The seed inspectors in the region don't even supervise the tags used by the seed producers to identify their lots.

Varieties under cultivation

30 years after their release, Deltapine 90 and Acala SJ2, two US varieties bred for irrigated cotton, are still largely grown commercially everywhere in Ethiopia. According to research results and industrial users' says, they don't correspond any more to present standards, in particular for their productivity, ginning out-turn, and fiber quality, which could penalize the Ethiopian cotton on both national and international markets.

Table 4 – Performance of varieties in commercial production

Variety	Registered	Year	Origin	Yield q/ha	GOT %	FL mm	Stage
Claudia	EAID PLC	2014	Australia	38.4	45.7	30.9	Basic
DP 90	Deltapine	1989	USA	38.6	34.8	27.7	Certified
Acala SJ2	USDA	1986	USA	32.5	34.2	28.6	Certified

Source: WARC, EIAR; GOT: ginning out-turn, FL: fiber length

However, today, the preference of the growers is going to the variety Claudia. This variety combines a good yield potential, superior to Acala SJ2 and similar to Deltapine 90, very high GOT and rather exceptional fiber length (table 4). Largely grown in Turkey, Claudia was initially bred in Australia. It

was imported by the company EAID and released by the NRVC in 2014. It is now under testing in large scale farms both in irrigated and rainfed areas. It has also been multiplied and distributed to small scale farmers in Tigray and Amhara[2].

Release of varieties

The National Variety Release Committee (NVRC) decides the registration of a new variety in the National Variety Register (NVR). It has 11 members, 2 representing the Ministry of Agriculture (MoA), 7 from the EIAR main regional Agricultural Research Centers (Tigray, South, Oromia, Amhara, Debrezeit, Melkassa), and 2 from Haramaya (Dire Dawa) and Hawasa Universities.

To be released, a new variety has to described (Distinction, Uniformity, and Stability or DUS criteria), and tested by WARC, 1 year if it is an Adaptation and Evaluation trial, and 2 years if it is a National Variety trial. The technical committee in charge of producing the report to the NVRC is composed of an agronomist, a breeder, an entomologist, and a biodiversity specialist. The information entered in the NVR is listed in table 5.

Table 5 – Criteria entered to describe a cotton variety in the National Variety Register

Group	Criteria
Agronomy	Adaptation area (altitude, rainfall, soil type), planting period, seed rate, fertilizer rate
Botany	Growth habit, petal color, days to initial flowering, days to initial boll opening, days to 65% maturity, plant height
Productivity	Boll number, average boll weight, ginning out-turn
Fiber quality	Length, fineness, strength, uniformity index
Suitability	Mechanical harvesting, trash
Admin	Year of release, breeder/maintainer

Source: NVR, 2018

Exotic varieties may be imported with a permit of the MoA. They also have to be evaluated by the technical and national committees before entering the national register.

In 2015, a change in the Biosafety regulation has allowed the importation of Genetically Modified Organisms (GMO) for confined experiment. Several cotton varieties, hybrid and GMO, have been introduced from India by the company JK Agri Genetics and approved by the NVRC. However, they did not perform well enough (table 6) compared to the cost of the seed, and they were not multiplied at a large scale[3]. However, they are currently under production in limited areas in Gambela Region by commercial farmers.

Table 6 – Cotton varieties in the 2018 Crop Variety Register

Variety	Registered	Year	Origin	Yield q/ha	GOT %	FL mm	Comments
JKCH 1947	JK Agri Genetics	2018	India	30.6	39.4	27.8	Bt cotton, imported
JKCH 11050	JK Agri Genetics	2018	India	30.5	39.2	28.4	Bt cotton, imported
DP 90	Deltapine	1989	USA	38.6	34.8	27.7	Commercial

Source: WARC-EIAR; Bt: Bacillus thuringensis; GOT: ginning out-turm, FL: fiber length

[2] The NGO Solidaridad has played a key role in the promotion of Claudia.
[3] More generally, the experiences in Burkina and India show that GMO varieties can be beneficial to the farmers – and the environment – but also increase the risks of failure in lousy rainfed conditions.

Cotton breeding

Legal issues on breeding activities

The framework of plant breeding, including plant breeder's and farmer's rights and duties, has been described in the Plant Breeders' Right Proclamation 481/2006, adopted by the government in 2006.

The application of the law is in the hand of the Ministry of Agriculture. It may decide to put restrictions on all rights, against compensation, and for various reasons, including prevention of monopoly, imported seed or food security.

Professional plant breeders must be licensed by the MoA. They have the right to sell and produce, including the right to license other persons to sell and produce the seed or propagating material of the protected variety. The right shall exist for 20 years in the case of annual crops and 25 for perennial ones.

For breeding purposes, a protected variety can be used as an initial source of variation.

Any person or farmers' community may propagate, grow and use a protected variety for other uses than commerce, for use as a food, for use within a farm. Farmers have also the rights to (a) save, use, exchange and sell farm-saved seed or propagating material of farmers' varieties; b) use protected varieties including material obtained from gene banks or plant genetic resource centres to develop farmers' varieties; c) save, use, multiply, exchange and sell farm-saved seed or propagating material of protected varieties. However farmers cannot sell farm-saved seed or propagating material of a protected variety in the seed industry on commercial scale.

Status of GMO seed

The Biosafety (Amendment) Proclamation 896/2015, adopted in 2015, declares that any activity related to the release of GMO in the environment requires an agreement of the Ministry of Environment and Forest (MoEF), valid for ten years. A special permit is also required from the MoEF for importation, valid for 3 months, or contained use (such as field trial, in conditions to prevent unintended impact on human, animal or external environment), valid for 5 years.

It also establishes a National Biotechnology Advisory Committee, accountable to the MoEF.

Cotton Research

The Ethiopian Institute of Agricultural Research (EIAR) has a mandate on Cotton research. Since the 70ies, it has been implemented for the whole country in the Awash valley, at the Werer Agricultural Research Center (WARC).

Cotton research is organized in four departments, *ie* Breeding, Socio-Economics and Extension, Agronomy, and Entomology. The global coordination is managed by one of the cotton breeders. Most activities are conducted under irrigation, on the station or nearby as there is little possibility to travel in the cotton growing regions. In particular, there is no research or testing done for the cropping systems under natural rainfall. The other research stations, located in the rainfed area, have not enough resources to conduct experiments on cotton.

The relation with stakeholders is organized through personal contacts or in the frame of the annual research review forum and the annual stakeholder meeting, where farms, agricultural services and cotton producers association participate. A team, formed by extensions specialists, is in charge of

monitoring the on farm testing and adoption of research results in the Afar region (15 sites). Once a year, the research team is conducting some training for irrigated cropping.

Plant breeding

The breeding department of WARC has a conventional breeding program. The aim is to produce open pollinated varieties adapted to irrigated conditions. The crosses realized each year are followed by selfing and visual single plant selection, when the crop has fully opened, within each generation until F7. The promising lines are tested in a Preliminary trial (2 environments or years), and then in a Multi-location trial (6 locations with irrigation in Werer, Gewane / Afar, Shaleko / Afar, Omorate / South region, Sille / Southern region, Weyto / Southern region).

Box 5. The cotton breeding team
Three scientists are part of the cotton breeding team.
Mr. Merdasa BALCHA, MSc in Plant Breeding, is also coordinating the whole cotton program. He has a 3 years' experience as a junior researcher and 2 as a plant breeder.
Mr. Donis GURMESSA, MSc in Biotechnology, has a 9 years' experience in plant breeding.
Mr. Samuel DAMTEW, MSc in Plant Breeding, has a 6 years' experience in cotton breeding.

Main challenges: human and financial resources; support for research in the rainfed area

For irrigated cropping system, yield is the first criteria, as there is no premium for quality. The breeding program is interested to include criteria for harvest mechanization such as plant compactness, reduced height, uniformity of opening and maturity, but there is at present no harvesting machine for practical experimentation. The HVI laboratory run by ETIDI is analyzing 500 to 1000 samples each year for the breeding department, at no cost. However, this is not sufficient to screen single plants for fiber quality.

The department could recently identify several varieties which could compete with Deltapine 90 (DP 90), or even Claudia. The varieties Sisikuk or Malkasadi could be alternatives DP 90 and to the modern variety Claudia, except for fiber length (table 7). Both varieties are now released and described in the National Variety Register.

Table 7 – Recent varieties released by the cotton breeding department of WARC

Variety	Registered	Year	Origin	Yield q/ha	GOT %	FL mm	Comments
Malkasadi	WARC	2019	Ethiopia	46.8	38.4	29.1	Local breeder
Sisikuk	WARC	2015	Ethiopia	40.7	44.8	28.8	Local breeder
Werer-15	WARC	2015	Ethiopia	43.0	39.0	27.7	Local breeder
Claudia	EAID PLC	2014	Australia	38.4	45.7	30.9	Tested on farms
DP 90	Deltapine	1989	USA	38.6	34.8	27.7	Commercial

Source: WARC-EIAR; GOT: ginning out-turm, FL: fiber length

The breeding department has also produced and released two *G. barbadense* varieties for specific markets in 2019. WARC-LS1 and WARC-LS2 are showing a long fiber which exceeds 33 mm, but their yield remains below 25 q/ha and their GOT below 38%.

The department is also in charge, for the MoA, to conduct the National variety evaluation trial to describe and assess the performance of the candidate varieties to release. These varieties may have been produced locally or introduced from other countries. For the locally bred varieties or the

introductions which have never been released anywhere worldwide, the trial is conducted in 6 different environments under irrigation, *e.g.* 3 locations x 2 years.

At last, the breeding program is maintaining a germplasm collection of 800 to 1000 varieties (renewed every two year). The germplasm is planted every two years to secure the availability of viable seed[4]. It is also multiplying in larger 200-300 m² plots the breeder's seeds of major varieties, doing roguing[5] and selfing.

On WARC research station, the Technology Multiplication department has the capacity to produce and condition about 10 tons of seed every year. In 2019, it has produced 6-7 tons of pre-basic and basic delinted seed of Deltapine 90, Werer-15, and Weyto-07. The seeds are then sold to the farms involved in seed multiplication.

Figure 6. Demonstration of manual spinning for the handicraft sector (left) and final product (right).

[4] There is a national gene bank run by the Ethiopian Biodiversity Institute (EBI). Its objective is to ensure the appropriate conservation and utilization of the country's biodiversity. However, it does not deal with cotton.
[5] Roguing means eliminating in the field the plants with undesirable traits.

Cottonseed processing and storage

Harvesting, and transport

There is no specific recommendation for harvesting or transport of the seed cotton in relation with seed production. To maximize the chances to satisfy the standards on the final product, the seed farms prefer to harvest the seed from the best performing plots, well developed and protected from pests. They store and transport the seed cotton in separated lots, in bags, depending on the variety or origin. However, if the seed has been produced by some out-grower, there is no way to control the quality of the seed.

Ginning, delinting and dressing

Most ginning plants are equipped with humidifiers to maintain the fiber quality when the seed cotton is too dry. This also prevents from seed crushing and damaging during the ginning process.

Once ginned, the seed may be either conditioned as fuzzy seed, delinted or delinted and dressed, depending on the order passed by the clients of the seed producer. Fuzzy seeds are generally sold in bulk, without any dressing. At the farm, they are sometimes coated with mud to avoid conglomerating. Delinting is done with sulfuric acid. The fuzzy seed is mixed with acid in a concrete mixer at a rate of 1 l acid for 12 kg seed[6]. On demand, it is then dressed with systemic insecticides, such as Cruiser (Thiametoxan) at the rate of 1 litre for 300 kg seed or Gaucho (Imidacloprid) at 1 liter for 200 kg.

At this point, germination tests may be done. Some operators are sowing the seed samples directly in the soil, on beds covered with a cloth. Others use trays and soft wet paper, in a simple seed testing laboratory, where samples can be kept on shelves.

Labelling and storage

The processed seed is generally packed and stored in 50 kg polypropylene bags. It will be used on the farm or sold to other farms. In absence of control, the bags are not labelled according to the standards, and the client must be confident with its furnisher. Delinted and dressed seed is sold at a price of 60 EB/kg (about 3 times the price of the seed cotton paid to the out-growers).

Table 8 – Recent varieties released by the cotton breeding department of WARC

Seed type	Price (EB / kg)	Ratio to SC price	Seed rate (kg / ha)	Equivalent in SC (kg/ha)
Fuzzy	12	0.6	45	27
Delinted	50	2.5	12.5	31
Delinted-dressed	60	3.0	12.5	38
GMO	1150	57.5	2.5	144

Indicative seed cotton price: 20 EB/kg

[6] In Tanzania, the acid delinting plant managed by Quton is consuming about 25 kg of sulfuric acid per ton of fuzzy seed (density 1.83 g/cm^3), *i.e.* 18% of the quantity of acid used with the concrete mixers

As a comparison, Sodecoton, in Cameroon, plans to build a delinting plant on the basis of a cost ratio of 1 kg of delinted and dressed seed to 2 kg of seed cotton, *ie* four times the selling price for fuzzy seeds[7].

Figure 7. Storage shade for the seeds produced on the farm.

Both formal and informal seed suppliers use common warehouses (no cold room, no disinfection any other special treatment.

The seed produced in one region may often be transported and distributed in other regions of the country.

Figure 8. Various aspects of the work done by the ginnery. From left to right and top to bottom. Separation of the cotton seed lots according to their geographic origin and destination. Unloading of seed cotton for ginning. Quality control on seed at the lab (see the yellow germination tray). Fiber and seed quality control of the seed cotton before ginning.

[7] Bachelier B., Palaï, O., 2020. Support program to the cotton seed supply chain in Sub-Saharan African countries. Work Package 1: Baseline studies. Mission report in Cameroon16-23 January 2020, 31 pp. + Annexes

Main challenges and recommendations

The SWOT exercise summarizes the main characteristics of the cottonseed sector in Ethiopia (fig. 3).

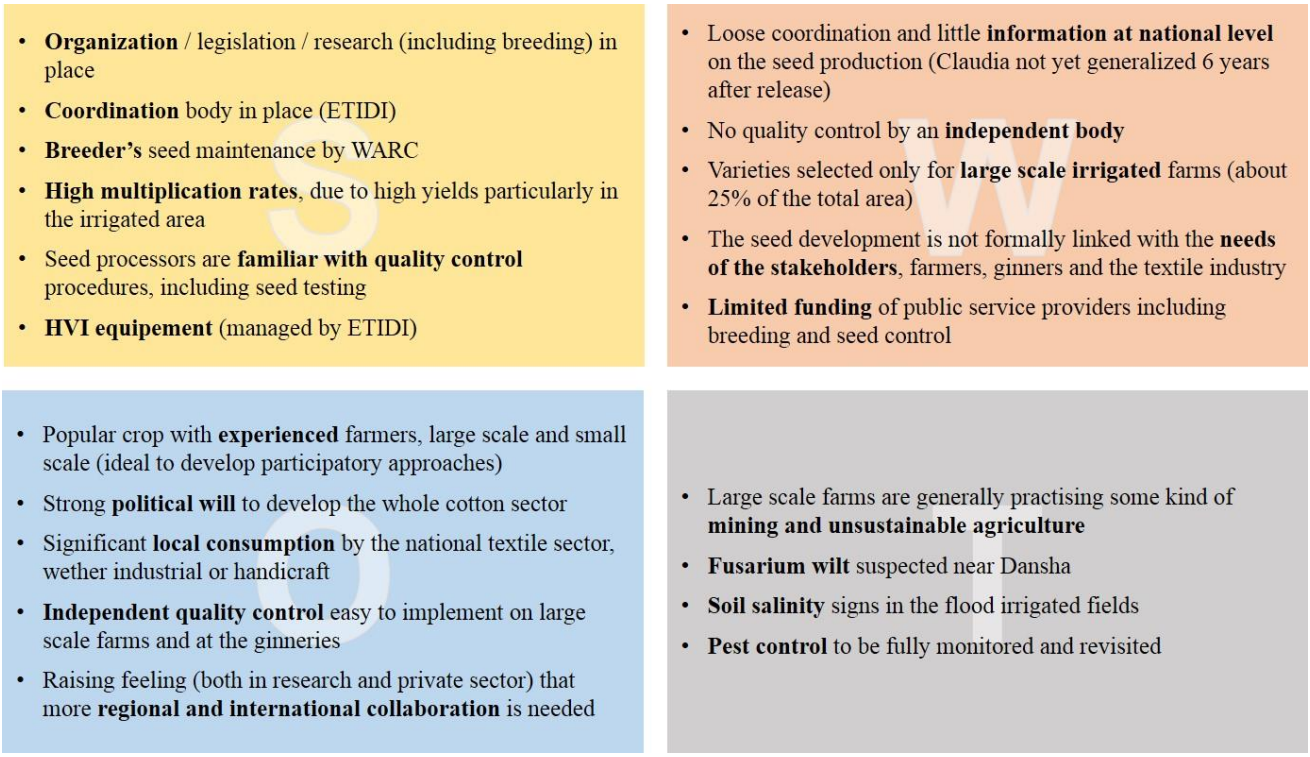

Figure 9. SWOT (Strength – Weakness – Opportunities – Threats) in cottonseed cotton production in Ethiopia.

In this section, we wish to focus on few challenges that are directly related to seed production. They have been selected because we thought that local actors could take action at short notice to improve the situation. They are summarized at table 9.

Of course, other challenges could have been considered as more important, such as the lack of resources for research and seed inspection, or the access to inputs for the farmers. But solving such issues will greatly depend on factors which are not relevant to this study: national and international policies, cotton prices and the economic value generated by the entire cotton chain, from production to industry. These are already considered in the national cotton development strategy.

Table 9 – Recap of the main challenges identified and suggestions proposed

Theme	N°	Challenge	Suggestion
Coordination and regulation	1	Global coordination	MoA-MTI and SH to formalize
Seed multiplication	2	Sustainability of production systems	Seed farmers chart
Breeding and research	3	Diversification of needs	Participatory setting
	4	Genetic diversity	Networking
	5	Cooperation with users	Participatory designs
	6	Experienced personnel	Incentives
Seed processing	7	Quality monitoring	Support and control

Coordination and control

1. Policing

Challenge. At the national level, there is little visibility concerning the production and use of each type of seed (fuzzy, delinted and dressed) and category (breeder, pre-basic, basic, certified) available at the national level. Although there seems to be some coordination activities in place, such as for the deliverance of Certificates, the global governance, coordination and monitoring processes of the seed sector are not very well described.

Proposition. Organize a concertation between MoA and MTI to design a seed multiplication process that includes a quality control process. The process should secure all the seed multiplication stages, avoid left-overs, and take full advantage of the high yielding irrigated farms. Besides, the quality control should be independent from the seed producers, not costly (random) and efficient (persuasive incentives and dissuasive penalties)

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Seed multiplication

2. Sustainability

Challenge. Large scale farms have often prioritized investments in view of short term profitability (field preparation, machines, management), and the cropping system in place is not environment friendly or sustainable. Few and temporary shelters or roads, wide open fields with rare trees, intensive ploughing and mono-cropping do not guarantee long term sustainability of most of these farms.

Proposition. Develop a chart with the large scale cotton farms for sustainable cottonseed production, as a condition to get the Certificate of competence for cotton seed multiplication.

***

Breeding and research

4. Diversity

Challenge. The breeding section maintains a collection of rather ancient varieties, and genetic diversity is not sufficient to face new constraints or improve the performance of the cotton sector.

Proposition. Network with other national cotton breeding programs and international gene banks. For example, it is possible that varieties, grown in other African countries, with natural rainfall, perform well enough in Ethiopia to replace advantageously the present varieties bred and tested under irrigation. Such introductions must be done through agreements.

***

3. Diversification

Challenge. For historical and practical reasons, the program has been focusing on irrigated cotton and manual harvesting. With time, new constraints are raising, such as salinity in the irrigated area, mechanical harvesting for large farms, rainfed cotton, longer fiber for the industry, or clean cotton for the local hand looms.

Proposition. As a primary step towards diversification, design a set of specific breeding programs, instead of a single one. This could be initiated by designing, in collaboration with the beneficiaries, specialized sets of specifications (Example shown at table 10).

Table 10. An example of Set of Specification (SoS) for the development of a cotton variety in Benin.

Items of the SoS	Description
Breeding objective	A cotton variety adapted to sowing as a second cycle crop (after maize or cowpea), rainfed, mechanised, high planting density, with GOT and quality equal to the commercial variety, for the Savalou region (Benin) where labour is becoming scarce (mechanical harvest)
Breeding criteria	Fast settling, short internodes, reduced height, limited vegetative growth, grouped boll opening, GOT superior to 44%, seed index superior to 8,5g, length > 27,5 mm, Micronaire > 4,2, +b < 10, tolerance to Bacterial blight and Jassids (hairiness)
Evaluation criteria	Levels acceptable in comparison with the commercial variety
Resources	Germplasm: MAR, Chaco 520, Rockett (*etc.*), and local varieties Finance: they must be guaranteed by the client-partners for the course of the program, at least 10 years Others (land, analysis of fiber, *etc.*): …

Not relevant for Ethiopia

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5. Participation

Challenge. Cotton research is not enough articulated with the needs of the cotton sector. The communication with beneficiaries and stakeholders is limited, and the challenges of rainfed cotton have to be more considered, whereas the scientists have little resources to travel and visit regularly the different cotton growing areas.

Proposition. Develop participatory activities, in particular with the cotton farmers, small and large scale, who are recognized in their community as cotton experts and innovative farmers. This can help, in particular, to assess the constraints in the rainfed areas (rainfall pattern, climate change, biotic constraints such as Jassids, B. blight or F. wilt), or test alternative technologies (cropping

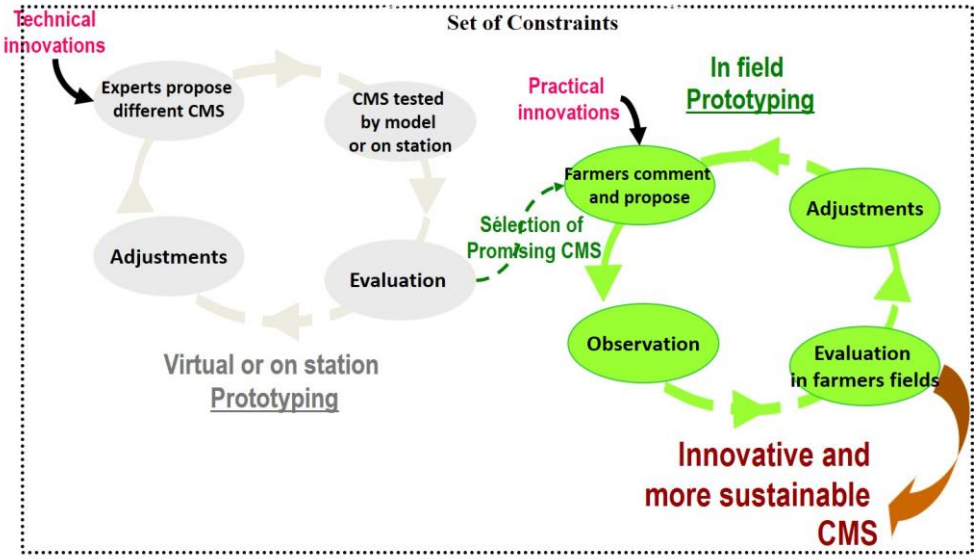

Figure 10. Two phases for the production of innovative and more sustainable Crop Management Systems (CMS), after Lançon et al, 2008.

systems, broadcast planting, alternative to chemical pesticides), or monitor the status of diseases and pests with cell phones (Examples of participatory approach done in cotton research are described in Lançon and al (2008) for the development of crop management systems as illustrated in Figure 4, and to Lançon and al (2004) for the decentralized development of new varieties).

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6. Attraction

Challenge. It seems difficult to attract and secure experienced personnel in the lowland area, at WARC in particular. Environment is harsher there, malaria occurs, and people prefer to be posted at higher altitude.

Proposition. EIAR and ETIDI should work on incentives for the personnel, including the researchers, posed at WARC.

***

Seed processing

7. Quality

Challenge. The producers are ensuring themselves the quality of their seed. They need both support and supervision to perform well. The development of the cotton sector will increase the number of actors involved and the trust between seed producers and seed users will have be based on other criteria than personal relationship, which is now the basis.

Proposition. Support the seed producers by training the staff involved in quality management (ginners and internal controllers) and by boosting the farms to put in place and maintain the required labs and equipment. As suggested in proposition 1, put in place an external seed control and increase the number of random seed testing by MoA or regional laboratories.

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